

## 1. Arizona Dairy Company

*Plug Flow Dairy Digester*

GENERAL FACILITY INFORMATION	
Location	Higley, AZ
Contact/Source	Dan Burch -- (602) 380-7955
Farm Type	Dairy- 15,000 total head with 5,000 milk cows.
Utility	Not applicable.
BIOGAS SYSTEM INFORMATION	
Digester Type	Three (3) plug flow units with Hypalon cover material.
Year Installed	1982
Designer/Installer	W.J. Jewell, Microgen Corp.
Gas Production	Based on electricity generation, 115 -210 thousand ft <sup>3</sup> /day (60% CH <sub>4</sub> ); maximum capacity of 440 thousand ft <sup>3</sup> /day
End Uses of Biogas	Electricity used on farm; fulfills over two-thirds of farm's electricity demand
Engine Type	398 Caterpillar engine; 500-kW generator.
Operational Mode	Parallel
Utility Contract	No Sale, excess electricity given to utility.
Electricity Production	Estimated between 1.3 and 4 million kWh/yr., with the engine/generator operating between 8 to 24 hours daily.
End Uses of Effluent	Liquids are spray irrigated onto intensive drying area. Dry solids recovered, sold to greenhouse industry.
Operational History	Tank cleanings required about once every two years due to desert sand; each tank cleaning requires digester(s) to be shut down for two to three weeks.
Routine Maintenance	6-8 hr./day mixing manure and feeding digesters; no pumps between digesters.
COST & REVENUE INFORMATION	
Capital Cost	\$300,000 for initial system (1982).
O&M Cost	\$12,000-\$15,000 /year.
Electricity Offsets	Estimated between \$125,000 and \$160,000 /year. \$0.098 is the current peak kWh charge, with no demand charge. The off-peak rate is \$0.04/kWh.
Heating Benefits	Production: None. Offsets: Not available.
Estimated Financial Performance	IRR(%): Not available. Payback(yr.): Estimated to be less than three years by owner.
OPERATOR COMMENTS:	
What do you like about your system?	
What would you change about your system?	
Other Comments:	
<i>Out of service as of summer 1996 due to change in ownership and loss of operator.</i>	
Source: 1. Personal Communication with W.J. Jewell, May 1997. 2. Personal Communication with Dan Burch, Arizona Dairy Company, 1997; 3. DOE, 1995 "Methane Recovery from Animal Manures: A Current Opportunities Casebook," August 1995.	

## 2. Langerwerf Dairy

*Plug Flow Dairy Digester*

GENERAL FACILITY INFORMATION		
Location	Durham, CA	
Contact/Source	Leo & Linda Langerwerf -- (916) 893-3131	
Farm Type	Dairy- 400 head	
Utility	Pacific Gas and Electric	
BIOGAS SYSTEM INFORMATION		
Digester Type	Plug flow with Hypalon cover material.	
Year Installed	1982	
Designer/Installer	Resource Conservation Management, Inc. / Lee Miller	
Gas Production	30,000 ft <sup>3</sup> /day (60% CH <sub>4</sub> )	
End Uses of Biogas	Electricity production with thermal reclaim used for milking facility hot water heating and residential space heating.	
Engine Type	3306 Caterpillar engine; 85-kW generator.	
Operational Mode	Parallel-Induction	
Utility Contract	Net Metering	
Electricity Production	Estimated at 300,00 kWh	
End Uses of Effluent	Liquids are spray irrigated onto croplands; solids are used as bedding and sold as garden mulch. Excess solids are land-applied.	
Operational History	No major problems; slow initial start-up due to lack of manpower and operating knowledge; recent engine overhaul now requires digester temperature to be maintained at 103°. A greenhouse cover over digester protects it from wind damage and rainwater collection.	
Routine Maintenance	2 hrs/day feeding digester and adding oil to engine-generator.	
COST & REVENUE INFORMATION		
Capital Cost	\$200,000	
O&M Cost	Not available.	
Electricity Offsets	\$36,000 /year	
Heating Benefits	Production: \$5,000/year	Offsets: \$15,000 /year
Estimated Financial Performance	IRR (%): Not available.	Payback (yrs): Not available.
OPERATOR COMMENTS		
What do you like about your system?		
What would you change about your system?		
Other Comments:		
Manure solids sales are approximately \$6,000 /year. Annual savings from the reduced number of manure pit clean outs is \$9,000.		
Source: 1. Personal Communication with Mr. And Mrs. Langerwerf, 1997.		
2. DOE, 1995 "Methane Recovery from Animal Manures: A Current Opportunities Casebook," August		

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## 3. Royal Farms

*Flushed Swine Manure Covered Lagoon*

GENERAL FACILITY INFORMATION	
Location	Tulare, CA
Contact/Source	Roy Sharp -- (209) 688-2051
Farm Type	1,650 sow farrow-to-finish swine farm
Utility	Southern California Edison
BIOGAS SYSTEM INFORMATION	
Digester Type	Three cell lagoon; one cell covered with Hypalon cover material.
Year Installed	1982 (Part 1); cover expanded 1987 (Part 2)
Designer/Installer	Jeff Chandler / Sharp Energy
Gas Production	70,000 ft <sup>3</sup> /day (70-80% CH <sub>4</sub> )
End Uses of Biogas	Electricity production with hot air reclaim used for supplemental heating in nursery barns.
Engine Type	75 kW Waukesha induction generator modified by Perennial Energy initially installed. 100 kW Waukesha installed during expansion.
Operational Mode	Parallel
Utility Contract	Surplus Sale; Double Metering
Electricity Production	Estimated at 700,00 to 750,000 kWh
End Uses of Effluent	Effluent recycled from third lagoon is used for parlor flushing . The excess is irrigated.
Operational History	No major problems; the lagoon has never needed cleaning.
Routine Maintenance	2 hrs/day feeding digester and adding oil to engine-generator.
COST & REVENUE INFORMATION	
Capital Cost	Approximately \$220,000.
O&M Cost	\$8,000/year.
Electricity Offsets	\$44,000 /year in offset power bills and excess sales at \$0.026/kWh.
Heating Benefits	Production: Not available. Offsets: \$5,000 /year
Estimated Financial Performance	IRR (%): 34% Payback (yrs): 4
OPERATOR COMMENTS	
What do you like about your system?	
What would you change about your system?	
Other comments: <i>Mr. Sharp has installed floating lagoon covers on two additional swine farms: Sharp Ranch (550 sows), and Caruthers Ranch (900 sows).</i>	
Source: 1. Personal Communication with Mr. Sharp, 1997 2. DOE, 1995 "Methane Recovery from Animal Manures: A Current Opportunities Casebook," August 1995.	

## 4. Churchill Co-op

*Covered Lagoon for Swine*

GENERAL FACILITY INFORMATION	
Location	Hecton, MN
Contact/Source	Kevin Fischer -- (320) 235-0044
Farm Type	Hog
Utility	Not applicable.
BIOGAS SYSTEM INFORMATION	
Digester Type	Covered Lagoon for odor control - Permalon X-210 material.
Year Installed	1996
Designer/Installer	Permalon/Reef Industries Inc./Baumgartner Environics, Inc.
Gas Production	Not available.
End Uses of Biogas	Installing a prototype non-thermal plasma system to reduce odor compounds in gas stream, University of Minnesota, 1997.
Engine Type	None.
Operational Mode	Not applicable.
Utility Contract	Not applicable.
Electricity Production	Not applicable.
End Uses of Effluent	Injection.
Operational History	Odors were reduced dramatically after cover installation. Neighbors noticed the changes and reported the improved air quality to the owner/operator, Kevin Fischer.
Routine Maintenance	Not available.
COST & REVENUE INFORMATION	
Capital Cost	\$34,000 for cover and installation.
O&M Cost	Not available.
Electricity Offsets	None.
Heating Benefits	Production: None. Offsets: None.
Estimated Financial Performance	IRR (%): Not applicable. Payback (yrs): Not applicable.
OPERATOR COMMENTS	
What do you like about your system?	
What would you change about your system?	
Other comments:	
<i>Sources:</i> 1. Personal Communication with Dennis Olheiser and Lynn Ciolli, Reef Industries, Inc., 1997. 2. Personal Communication with Richard Nicolai, University of Minnesota, 1997. 3. John Baumgartner, Baumgartner Environics, Inc., (320) 848-6304.	

## 5. McCabe Farms

*Complete Mix for Swine Manure*

GENERAL FACILITY INFORMATION		
Location	Mt. Pleasant, IA	
Contact/Source	Rich McCabe -- (319) 385-2139	
Farm Type	150 sow farrow-to-finish swine farm	
Utility	Not applicable.	
BIOGAS SYSTEM INFORMATION		
Digester Type	Buried concrete slurry tank with no mechanical mixing.	
Year Installed	1972	
Designer/Installer	Harold McCabe	
Gas Production	Never metered.	
End Uses of Biogas	Flared.	
Engine Type	None.	
Operational Mode	Not applicable.	
Utility Contract	Not applicable.	
Electricity Production	Not applicable.	
End Uses of Effluent	Twice a year, about 9,000 gallons of effluent and sludge are removed from the digester and land applied. The remaining solids consist primarily of lignin, which acts as a soil tilth and conditioning agent.	
Operational History	Temporarily shut down to replace internal plumbing	
Routine Maintenance	Feed tank and check temperature.	
COST & REVENUE INFORMATION		
Capital Cost	\$20,000.	
O&M Cost	\$2,500 for natural gas.	
Electricity Offsets	Not applicable.	
Heating Benefits	Production: Not applicable.	Offsets: Not applicable.
Estimated Financial Performance	IRR(%): Not applicable.	Payback (yrs): Not applicable.
OPERATOR COMMENTS		
What do you like about your system? <i>The simplicity of no moving parts.</i>		
What would you change about your system? <i>Insulate the side walls of digester tank in ground to reduce winter heating costs by 50%.</i>		
Other comments: <i>Digester was built to eliminate odor and control pollution because his farm was within city limits; first animal waste digester in U.S.; system heated by natural gas instead of biogas.</i>		
Source: 1. Personal communication with Rich McCabe. 2. DOE, 1995 "Methane Recovery from Animal Manures: A Current Opportunit		

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## 6. Fairgrove Farms, Inc. *Plug Flow Digester for Dairy Manure*

GENERAL FACILITY INFORMATION		
Location	Sturgis, MI	
Contact/Source	David or John Pueschel -- (616) 651-6646	
Farm Type	700 head dairy	
Utility	Not available.	
BIOGAS SYSTEM INFORMATION		
Digester Type	Plug flow	
Year Installed	1981	
Designer/Installer	Perennial Energy	
Gas Production	35,000 to 50,000 ft <sup>3</sup> /day (60% CH <sub>4</sub> )	
End Uses of Biogas	Electricity production with thermal reclaim for digester heating.	
Engine Type	85 kW model 3306 Caterpillar modified by Perennial Energy.	
Operational Mode	Parallel Induction.	
Utility Contract	Buy All, Sell All.	
Electricity Production	Approximately 435,000 to 620,000 kWh at an 85% availability factor.	
End Uses of Effluent	Liquid is spread on fields, solids are used as bedding.	
Operational History	Very few problems. The digester usually runs at about 63 kWh. Every three or four years tank must be cleaned and water pipes checked; engine leak in manifold cracked engine head; sand trapped in feedstock caused heat exchanger to break	
Routine Maintenance	5 min/day maintaining two engines (one back-up engine)	
COST & REVENUE INFORMATION		
Capital Cost	\$200,000	
O&M Cost	\$25,407, including system depreciation.	
Electricity Offsets	\$38,500 - \$42,000 /yr	
Heating Benefits	Production: Not applicable.	Offsets: Not applicable.
Estimated Financial Performance	IRR(%): Not available.	Payback (yrs): 4
OPERATOR COMMENTS		
What do you like about your system?		
What would you change about your system?		
<i>Frontal heated area would include sand trap.</i>		
Other comments:		
<i>Source: 1. Personal Communication with John Pueschel, 1997.</i>		



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| 2. DOE, 1995, "Methane Recovery from Animal Manures: A Current Opportunities Casebook," August 1995. |
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## 7. Lindstrom Farms

*Complete Mix Dairy Digester*

GENERAL FACILITY INFORMATION	
Location	Welch, MN
Contact/Source	Mr. and Mrs. Duane Lindstrom -- (612) 258-4425
Farm Type	Dairy
Utility	Not available.
BIOGAS SYSTEM INFORMATION	
Digester Type	Mixed
Year Installed	1982
Designer/Installer	Designed by Bio-Gas of Colorado, installed by A.O. Smith.
Gas Production	5,070 ft <sup>3</sup> /day
End Uses of Biogas	Electricity used on farm; generates hot water for domestic use; rate charged by electric company of \$.08/kWh
Engine Type	Waukesha 155 engine; Perennial Energy generator; A.O. Smith tanks <sup>1</sup>
Operational Mode	Not available.
Utility Contract	Not available.
Electricity Production	Not available.
End Uses of Effluent	Fertilizer for 80 acres of feed corn.
Operational History	Cold weather engine start-up is major problem; new stirring mechanism installed to solve scum build-up problems; burned out generator valves at 5,500 hrs; overhauled engine; rewired control panel
Routine Maintenance	Not available.
COST & REVENUE INFORMATION	
Capital Cost	\$75,000
O&M Cost	Not available.
Electricity Offsets	Not available.
Heating Benefits	Production: Not available. Offsets: Not available.
Estimated Financial Performance	IRR(%): Not available. Payback (yrs): Not available.
OPERATOR COMMENTS	
What do you like about your system?	
What would you change about your system?	
Other comments:	
<i>Not operational due to change in farm operations.</i>	
Source: 1. Personal communication with Mr. and Mrs. Lindstrom.	
2. John Ashworth et al., "Universe of U.S. Commercial-Scale Anaerobic Digesters: Results of SERI/ARD Data Collection," May 30, 1985.	

## 8. Darrell Smith Farm

*Complete Mix Chicken Digester*

GENERAL FACILITY INFORMATION	
Location	Princeton, NC
Contact/Source	Darrell Smith -- (919) 734-6107
Farm Type	70,000 caged layer hen poultry farm
Utility	Carolina Power & Light
BIOGAS SYSTEM INFORMATION	
Digester Type	Heated complete mix (mesophilic), metal tank; converted to thermophilic operation, 1997.
Year Installed	Completed and on-line, 1983
Designer/Installer	Bio-Gas of Colorado / A.O. Smith Harvestore
Gas Production	21,000 ft <sup>3</sup> /day primary (62% CH <sub>4</sub> )
End Uses of Biogas	Electricity with thermal reclaim used for heating digester.
Engine Type	80-kW Minneapolis-Moline engine; Kato generator.
Operational Mode	Parallel Induction
Utility Contract	Buy All, Sell All
Electricity Production	520,000 kWh.
End Uses of Effluent	Landspread from lagoon, some waste is re-fed into digester.
Operational History	Engine-generator set and cooling system were undersized; cracked engine head due to faulty casting; control panel replaced due to H <sub>2</sub> S
Routine Maintenance	1 hr/ day monitoring digester.
COST & REVENUE INFORMATION	
Capital Cost	\$225,000 for primary system. \$25,000 for secondary system, including additional incidental costs due to nature of project.
O&M Cost	\$4,750 to 15,860.
Electricity Offsets	\$26,000; \$0.05/kWh is the current on-peak charge; no demand charge.
Heating Benefits	Production: Not available. Offsets: Not available.
Estimated Financial Performance	IRR(%):Not available. Payback (yrs): Not available.
OPERATOR COMMENTS	
<p>What do you like about your system?  <i>Can maintain consistent heat in the digester year round.</i></p> <p>What would you change about your system?  <i>Cone type bottom in digester tank.</i></p> <p>Other comments:  <i>The primary reasons for installing the digester were odor control and environmental concerns. Are converting to thermophilic to allow treatment of a variety of wastes. Contract with Carolina Power &amp; Light expires 1998.</i></p>	
<p>Source: 1. Personal communication with Mr. and Mrs. Smith, 1997;  2. Dr. Richard Vetter, A.O. Smith Inc., September 1996;  3. DOE, 1995 "Methane Recovery from Animal Manures: A Current Opportunities Casebo</p>	

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## 9. Cooperstown Holstein Co. Farm *Complete Mix Dairy Digester*

GENERAL FACILITY INFORMATION		
Location	Cooperstown, NY	
Contact/Source	Peter Huntington -- (607) 547-5053	
Farm Type	270 cow dairy	
Utility	New York State Electric and Gas Co.	
BIOGAS SYSTEM INFORMATION		
Digester Type	Mixed tank	
Year Installed	1985	
Designer/Installer	A.O. Smith Harvestore	
Gas Production	23,625 ft <sup>3</sup> /day (60% CH <sub>4</sub> )	
End Uses of Biogas	Heating Benefits for digester heating and pipelined to the Meadows Retirement Home for water and space heating. Install generator, 1997.	
Boiler Type	A.O. Smith, 120 gallon; LT Gas/Biogas fired	
Engine Type	Not applicable.	
Operational Mode	Not applicable.	
Utility Contract	Not applicable.	
Energy Production	17,000 to 18,000 gallons of fuel oil/year equivalent sold to the Meadows.	
End Uses of Effluent	Digester effluent is stored in slurry tank for later land-application on corn.	
Operational History	Compressor unit and circulation pump bearings rebuilt twice; slurry chopper rebuilt four times.	
Routine Maintenance	15 to 20 min/day of routine maintenance	
COST & REVENUE INFORMATION		
Capital Cost	\$500,000	
O&M Cost	\$4,125 plus labor expenses.	
Heating Benefits	Production: 30% of generated biogas used to heat digester.	Offsets: Estimated at \$10,600 at the 1993 price of fuel oil.
Estimated Financial Performance	IRR(%): Not available.	Payback (yrs): Not available.
OPERATOR COMMENTS		
What do you like about your system?		
What would you change about your system?		
Other comments:		
Ordered engine-generator; utility negotiations in progress December 1996		
Source: 1. Personal communication with Mr. Huntington, 1997. 2. Mark Moser, Resource Conservation Management, Inc., December 1996. 3. DOE, 1995 "Methane Recovery from Animal Manures: A Current Opportunities Casebook," August 1995.		



## 10. Agway Farm Research Center *Complete Mix Dairy Digester*

GENERAL FACILITY INFORMATION	
Location	Tully, NY
Contact/Source	Stan Weeks -- (315) 683-5700
Farm Type	250 milk cow dairy
Utility	Niagara Mohawk
BIOGAS SYSTEM INFORMATION	
Digester Type	Complete mix
Year Installed	1981
Designer/Installer	Stan Weeks/Agway
Gas Production	12,000 ft <sup>3</sup> /day (60% CH <sub>4</sub> )
End Uses of Biogas	Electricity with thermal reclaim used for digester and two buildings
Engine Type	18-kW Mercruiser (GM) marine engine modified by Perennial Energy
Operational Mode	Parallel Induction.
Utility Contract	Surplus Sale.
Electricity Production	145,000 to 150,000 kWh
End Uses of Effluent	Liquid effluent is stored and land applied, solids are used as bedding.
Operational History	In 1987, the digester was replaced with a larger, poured-concrete design to allow for higher pressures inside the digester, eliminating the need for a compressor. Conversion of system to separate solids before introduction into the digester eases materials handling.
Routine Maintenance	10 - 15 min/day spent monitoring system performance.
COST & REVENUE INFORMATION	
Capital Cost	\$175,000
O&M Cost	\$3,650
Electricity Offsets	\$17,000 to \$18,000 /year. \$0.12 is the current kWh charge, with no demand charge.
Heating Benefits	Production: 30% of energy is recovered as hot water. equivalent to 8,000 gallons of propane gas. Offsets: \$5,600 to \$5,800 at \$0.70 per gallon of propane.
Estimated Financial Performance	IRR(%): Not available. Payback (yrs): 6-7 years..
OPERATOR COMMENTS	
What do you like about your system?	
What would you change about your system?	
Other comments:	
Source: 1. Personal communication with Mr. Weeks, 1997. 2. DOE, 1995 "Methane Recovery from Animal Manures: A Current Opportunities Casebook," August	

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## 11. Mason Dixon Farms

*Plug Flow Digester for Dairy Manure*

GENERAL FACILITY INFORMATION	
Location	Gettysburg, PA
Contact/Source	Richard Waybright -- (717) 334-4056
Farm Type	2,000 milk cow dairy
Utility	Metropolitan Edison
BIOGAS SYSTEM INFORMATION	
Digester Type	Two plug flow digesters and one slurry-based loop digester
Year Installed	Plug 1: 1979; Plug 2: 1981, Loop: 1985
Designer/Installer	Plug 1: Energy Cycle, Inc. Plug 2 & Loop: Mason Dixon Farms
Gas Production	Never metered. Plug 1 estimated at 35,000 ft <sup>3</sup> /day. Total biogas production approximately 120,000 ft <sup>3</sup> /day.
End Uses of Biogas	Electricity with thermal reclaim used for heating digester and home.
Engine Type	Three 150-kW model G342 Caterpillar gas engine-generators.
Operational Mode	Parallel Induction.
Utility Contract	Not available.
Electricity Production	1.5 to 1.7 million kWh
End Uses of Effluent	Liquids used on croplands; digested solids are sold to local nurseries
Operational History	With improved heating system, loop digester eliminates solids crusting problem experienced with regular plug flow digesters. Two additional Caterpillar engines (400 kW combined) have been installed.
Routine Maintenance	15 minute check of engine oil and walk-through inspection daily. There has been one manual clean-out of Plug 1 to remove lime and grit.
COST & REVENUE INFORMATION	
Capital Cost	\$180,000 for Plug 1; modifications to engine-generator set and effluent handling system cost an additional \$80,000.
O&M Cost	Not available.
Electricity Offsets	\$92,000 /yr. \$0.06 is the current kWh charge, with no demand charge.
Heating Benefits	Production: Not available. Offsets: Not available.
Estimated Financial Performance	IRR(%): Not available. Payback (yrs): Not available.
OPERATOR COMMENTS	
What do you like about your system?	
What would you change about your system?	
Other comments:	
Source: 1. Personal communication with Mr. Waybright, 1997. 2. DOE, 1995 "Methane Recovery from Animal Manures: A Current Opportunities Casebook," August	

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## 12. Rocky Knoll Farms

*Modified Plug Flow for Swine Manure*

GENERAL FACILITY INFORMATION	
Location	Lancaster, PA
Contact/Source	Harlan Keener -- (717) 464-2669
Farm Type	1,200 head farrow-to-finish swine farm
Utility	Pennsylvania Power and Light
BIOGAS SYSTEM INFORMATION	
Digester Type	Modified plug flow
Year Installed	1985
Designer/Installer	Energy Cycle, Inc.
Gas Production	60,000 ft <sup>3</sup> /day. (60-62% CH <sub>4</sub> )
End Uses of Biogas	Electricity production with thermal reclaim. Reclaimed hot water used to supplement heating requirements of farrowing rooms and nursery.
Engine Type	200-kW model 342 Caterpillar engine-generator w/ general load displacement of 125 kW. A secondary 25 - kW genset runs during periods of excess biogas production.
Operational Mode	Parallel Induction.
Utility Contract	Not available.
Electricity Production	1.0 to 1.2 million kWh.
End Uses of Effluent	Land-spread on crops as fertilizer. Valued at \$15,000 annually.
Operational History	Two problems repaired in 1989: (1) building surrounding digester destroyed by hydrogen sulfide and replaced, and (2) leak in pipes caused electrolysis, requiring pipes to be replaced and zinc bar to be inserted.
Routine Maintenance	15 minute routine check of gauges.
COST & REVENUE INFORMATION	
Capital & O&M Cost	Capital: \$225,000 + \$100,000 for modifications; O&M: \$8,000 /yr
Electricity Offsets	\$60,000 to \$65,000. Current charge is \$0.06/kWh, no demand charge.
Heating Benefits	Production: Estimated equivalent of 12 gallons of propane per hour. Offsets: \$40,000 during heating season
Financial Performance	IRR (%): Not available. Payback (yrs): Not available.
OPERATOR COMMENTS	
What do you like about your system?	
What would you change about your system?	
Other comments: <i>Digester originally built primarily for odor control. As of 1996, temporarily out of hog business - currently digesting organic byproducts (dairy processing waste, including: cheese whey, and other cheese by-products).</i>	
Source: 1. Personal communication with Mr. Keener, 1997 2. Harlan Keener, 1996. 3.DOE, 1995, "Methane Recovery from Animal Manures: A Current Opportunities Casebook," August	

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### 13. Oregon Dairy Farms *Complete Mix Digester for Dairy Manure*

GENERAL FACILITY INFORMATION		
Location	Lititz, PA	
Contact/Source	George and Mary Hurst -- (717) 656-7305	
Farm Type	250 milk cow dairy.	
Utility	Pennsylvania Power and Light	
BIOGAS SYSTEM INFORMATION		
Digester Type	Slurry-based loop digester with Hypalon cover material.	
Year Installed	1983	
Designer/Installer	Richard Waybright (Mason Dixon Farms)/Oregon Dairy Farms	
Gas Production	Never metered.	
End Uses of Biogas	Electricity with thermal reclaim used for home heating.	
Engine Type	50-kW model G333 Caterpillar engine modified for dual-fuel operation.	
Operational Mode	Induction; electricity used on-site.	
Utility Contract	Not applicable.	
Electricity Production	200,000 to 250,000 kWh annually.	
End Uses of Effluent	Digested manure pumped to lagoon and land applied.	
Operational History	No major problems.	
Routine Maintenance	Daily monitoring of waste flow, pumps, and engine oil.	
COST & REVENUE INFORMATION		
Capital Cost	\$120,000 turn key	
O&M Cost	\$3,500 to \$4,000 /yr	
Electricity Offsets	\$12,000 to \$15,000/year. Current electricity charge is \$0.06/kWh, with no demand charge.	
Heating Benefits	Production: Not available.	Offsets: \$1,200 annually on home heating.
Estimated Financial Performance	IRR (%): Not available.	Payback (yrs): Not available.
OPERATOR COMMENTS		
What do you like about your system?		
What would you change about your system?		
Other comments:		
Oregon Dairy used R. Waybright's basic digester design from Mason Dixon Farms, with modifications for own needs.		
Source: 1. Personal communication with Mr. Hurst, 1997.		
2. DOE, 1995 "Methane Recovery from Animal Manures: A Current Opportunities Casebo		
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## 14. Valley Pork

*Complete Mix Digester for Swine Manure*

GENERAL FACILITY INFORMATION	
Location	Seven Valleys, PA
Contact/Source	Jim Yoder -- (717) 229-2988
Farm Type	1,650 sow farrow-to-finish swine farm
Utility	Pennsylvania Power & Light
BIOGAS SYSTEM INFORMATION	
Digester Type	Complete Mix
Year Installed	1986
Designer/Installer	Resource Conservation Management, Inc. / Hershey Equipment
Gas Production	50,000 to 75,000 ft <sup>3</sup> /day (62-65% CH <sub>4</sub> )
End Uses of Biogas	Electricity used on farm; excess electricity sold to electric company. Hot water recovery for barn heat.
Engine Type	140-kW model T3306 Caterpillar engine-generator, operating at load displacement of 100 to 130 kW. Secondary 40-kW engine operates during periods of excess biogas production.
Operational Mode	Not available.
Utility Contract	Not available.
Electricity Production	775,000 to 850,000 kWh.
End Uses of Effluent	Liquids land-applied onto croplands.
Operational History	No major problems.
Routine Maintenance	Daily monitoring of waste pumps.
COST & REVENUE INFORMATION	
Capital Cost	\$250,000
O&M Cost	Estimated at \$5,000 /yr.
Electricity Offsets	Estimated at \$50,000 /yr, including sale of excess electricity. Current charge is \$0.05/kWh, with \$11.00 charge.
Heating Benefits	Production: Not available. Offsets: \$15,000 for the heating season.
Estimated Financial Performance	IRR (%): Not available. Payback (yrs): Not available.
OPERATOR COMMENTS	
What do you like about your system?	
What would you change about your system?	
Other comments: <i>As of mid 1995, temporarily out of hog business.</i>	
Source: 1. Mark Moser, Resource Conservation Management, 1996. 2. DOE, 1995 "Methane Recovery from Animal Manures: A Current Opportunities Casebook," August	

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## 15. Barham Farms

*Covered Lagoon for Swine Manure*

GENERAL FACILITY INFORMATION		
Location	Zebulon, NC	
Contact/Source	Julian Barham -- (919) 365-8400	
Farm Type	4,000 sow farrow-to-wean swine farm	
Utility	Carolina Power and Light	
BIOGAS SYSTEM INFORMATION		
Digester Type	Modular Covered Lagoon, with Permalon X-210 material.	
Year Installed	1996	
Designer/Installer	Cover: Resource Conservation Management, Inc./Julian Barham/USDA-Natural Resource Conservation Service. Engine: Caterpillar, Inc./Resource Conservation Management, Inc.	
Gas Production	Projected 36,000 ft <sup>3</sup> /day (winter) and 50,000 ft <sup>3</sup> /day (summer)	
End Uses of Biogas	Electricity used on farm; excess electricity sold to electric company; Heat recovery from radiator and exhaust heat farrowing house.	
Boiler Type	Burnham	
Engine Type	Caterpillar 3406, 120 kW	
Operational Mode	Parallel Induction.	
Utility Contract	Surplus Sale.	
Electricity Production	Projected 70 kW (winter) and 120 kW (summer).	
End Uses of Effluent	Spread on crops.	
Operational History	Start-up lagoon, Dec. 1996; Heat, Jan. 1997; Engine, Mar. 1997	
Routine Maintenance	Not available.	
COST & REVENUE INFORMATION		
Capital Cost	\$240,000	
O&M Cost	Not yet available.	
Electricity Offsets	Not yet available.	
Heating Benefits	Production: Not yet available.	Offsets: Not yet available.
Estimated Financial Performance	IRR (%): Not yet available.	Payback (yrs): Not yet available.
OPERATOR COMMENTS		
What do you like about your system?		
What would you change about your system?		
Other comments:		
1. Built using USDA-NRCS Interim Practice Standard #360		
2. Utility currently monitoring system for energy performance. Negotiations are incomplete.		



<i>Source:</i> Kurt Roos, EPA and Julian Barham, Barham Farm, 1997
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## 16. Craven Dairy Farms

*Plug Flow Digester for Dairy Manure*

GENERAL FACILITY INFORMATION		
Location	Cloverdale, OR	
Contact/Source	Jeff Craven -- (503) 392-4555	
Farm Type	600 cow dairy, expanding to 1,000	
Utility	Tillamook People's Utility District	
BIOGAS SYSTEM INFORMATION		
Digester Type	Plug Flow	
Year Installed	1996-97	
Designer/Installer	Resource Conservation Management, Inc./Craven Construction	
Gas Production	42,000 ft <sup>3</sup> /day from 650 cows	
End Uses of Biogas	Sale of electricity	
Engine Type	2 Ford 460, 65 kW engine- generators with heat recovery for farm use.	
Operational Mode	Parallel Induction.	
Utility Contract	Buy All, Sell All.	
Electricity Production	65 kW with 600 cows	
End Uses of Effluent	Fiber sold; liquid used for pasture and forage production.	
Operational History	New 1996. Water heaters eliminated due to engine heat recovery.	
Routine Maintenance	Oil and filters changed twice a month.	
COST & REVENUE INFORMATION		
Capital Cost	\$250,000	
O&M Cost	Not yet available.	
Electricity Offsets	Not yet available.	
Heating Benefits	Production: Not yet available.	Offsets: Not yet available.
Estimated Financial Performance	IRR (%): Not yet available.	Payback (yrs): Not yet available.
OPERATOR COMMENTS		
What do you like about your system? <i>Simplicity, quiet, produces something to sell.</i>		
What would you change about your system?		
Other comments: <i>System fully operational Feb. 1997.</i>		
<i>Source: 1. Personal communication with Rick Mattocks, Environomics, Inc., April 1997.</i>		

2. Mark Moser, Resource Conservation Management , Inc., November 1996.
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## 17. AA Dairy

*Plug Flow Digester for Dairy Manure*

GENERAL FACILITY INFORMATION	
Location	Candor, NY
Contact/Source	Bob Aman
Farm Type	500 cow dairy
Utility	New York State Electric and Gas
BIOGAS SYSTEM INFORMATION	
Digester Type	Plug Flow
Year Installed	1996-97
Designer/Installer	Resource Conservation Management, Inc./Aman Dairy
Gas Production	Not yet available.
End Uses of Biogas	Electricity used on farm; excess electricity sold to electric company.
Boiler Type	To be determined.
Engine Type	To be determined.
Operational Mode	To be determined.
Utility Contract	To be determined.
Electricity Production	Not yet available.
End Uses of Effluent	Spread on crops.
Operational History	Not yet available..
Routine Maintenance	Not yet available.
COST & REVENUE INFORMATION	
Capital Cost	est. \$200,000
O&M Cost	Not yet available.
Electricity Offsets	Not yet available.
Heating Benefits	Production: Not yet available.      Offsets: Not yet available.
Estimated Financial Performance	IRR (%): Not yet available.      Payback (yrs): Not yet available.
OPERATOR COMMENTS	
What do you like about your system?	
What would you change about your system?	
Other comments: <i>Under construction, Oct. 1996.; Engine planned, 1998</i>	

*Source:* Kurt Roos, EPA and Mark Moser, Resource Conservation Management, 1997.

## 18. Foster Brothers Farm

*Plug Flow Digester for Dairy Manure*

GENERAL FACILITY INFORMATION	
Location	Middlebury, VT
Contact/Source	Robert Foster -- (802) 388-0156; Don Brumfield (802) 388-1137
Farm Type	350 milk cow dairy
Utility	Central Vermont Public Service Corporation
BIOGAS SYSTEM INFORMATION	
Digester Type	Two parallel plug flow digesters with a single XR-5 cover material.
Year Installed	1982
Designer/Installer	Hadley & Bennett
Gas Production	28,000 ft <sup>3</sup> /day
End Uses of Biogas	Electricity used on farm; excess electricity sold to electric company at \$0.09/kWh (1982), less than \$0.02/kWh (1995); thermal reclaim used for digester heating.
Engine Type	Original: 125-kW model 353 Caterpillar engine-generator. With lower buy back rates, installed a 85-kW 3304 Caterpillar diesel engine modified to operate on a dual fuel (biogas & diesel) basis for load displacement. Generator upgraded to 100 kW to better match current dairy demand.
Operational Mode	Parallel.
Utility Contract	No contract. General order 65--sell as operators desire at less than \$0.015/kWh, therefore they have decided not to sell electricity to utility.
Electricity Production	Average of 1,250 to 1,400 kWh/day
End Uses of Effluent	Liquid effluent sprayed on fields. Solids are composted and sold as seven different soil amendments for retail trade as well as several products for lawn/garden growing mix. Add another retail line (4 items).
Operational History	No major problems; three manual clean-outs since 1982. Replaced wood wall between two digesters with concrete; separation equipment has been upgraded.
Routine Maintenance	Regular oil changes (every 300+ hours).
COST & REVENUE INFORMATION	
Capital Cost	\$185,000 initially; modifications to genset and effluent handling system cost an additional \$115,000; to use effluent solid material additional \$450,000 for potting soil and compost handling facility.
O&M Cost	\$8,000 to \$15,000
Electricity Offsets	When facility sold power, \$40,000 /yr. Current generation replaces purchase power charge of up to \$0.28/kWh charge, no demand
Estimated Financial Performance	IRR (%): Not available. Payback (yrs): Not available.
OPERATOR COMMENTS	
<p>What do you like about your system?</p> <p><i>More efficient use of nutrient, allows for better management, provides an additional source of revenue.</i></p> <p>What would you change about your system?</p> <p><i>Stone and sand sump in the receiving area, use of materials less subject to corrosion, slightly different layout.</i></p> <p>Other comments:</p> <p><i>Can't afford to sell excess at \$0.02/kWh so have not sold to utility for several years.</i></p>	
<p>Source: 1. Personal Communication with Robert Foster.</p> <p>2. DOE, 1995, "Methane Recovery from Animal Manures: A Current Opportunities Casebook," August</p>	

1995.
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## 19. M&amp;M Dairy

*Plug Flow Digester for Dairy Manure*

GENERAL FACILITY INFORMATION		
Location	Fontana, CA	
Contact/Source	Dr. Renato Lumbroso, BioRecycling Technologies, Inc. -- (909) 899-2982	
Farm Type	1,600 total head dairy, 400 milk cows	
Utility	Pacific Gas & Electric	
BIOGAS SYSTEM INFORMATION		
Digester Type	Two completely-stirred thermophilic reactors.	
Year Installed	1985 initially, as a modified plug flow operating as a completely stirred thermophilic reactor.	
Designer/Installer	BioRecycling Technologies, Inc.	
Gas Production	Presently 14,000 ft <sup>3</sup> /day (58-60% CH <sub>4</sub> ) from approximately 400 head.	
End Uses of Biogas	Process heat for heating digester and processing products.	
Engine Type	Not applicable.	
Operational Mode	Not applicable.	
Utility Contract	Not applicable.	
Electricity Production	Not applicable.	
End Uses of Effluent	The digester slurry is separated into solid and liquid fractions by mechanical separation and centrifuge. The solid fraction, after anaerobic digestion, is used as a liquid organic fertilizer and soil amendment (LOF), or is chemically amended as NutriPlus. The cake produced by the centrifugation is used as the base of a range of organic fertilizer and soil amendment pellets.	
Routine Maintenance	Daily feeding and inspection to ensure proper digester temperature and operation. Normal preventive maintenance of equipment.	
COST & REVENUE INFORMATION		
Capital Cost	Not available.	
O&M Cost	Not available.	
Electricity Offsets	Not applicable.	
Heating Benefits	Production: Not available.	Offsets: Not available.
Estimated Financial Performance	IRR (%): Not available.	Payback (yrs): Not available.
OPERATOR COMMENTS		
What do you like about your system? <i>This is a zero discharge system, converting environmentally polluting material into a full range of useful and valuable products for agriculture, horticulture, and retail markets.</i>		
What would you change about your system? <i>Expand range of products by fine tuning them for a series of specialized markets.</i>		
Other comments: <i>This operational plant was conceived as a pilot plant that developed and demonstrated new technology and products.</i>		
Source: 1. Personal communication with Dr. Lumbroso.		



2. DOE, 1995, "Methane Recovery from Animal Manures: A Current Opportunities Casebook," August 1995.
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## 20. Carroll's Foods, Inc.

*Covered Lagoon for Swine Manure*

GENERAL FACILITY INFORMATION	
Location	Warsaw, NC
Contact/Source	Bob McLeod -- (919) 293-3434
Farm Type	1,000 sow farrow-to-finish swine farm
Utility	Four County EMC
BIOGAS SYSTEM INFORMATION	
Digester Type	Covered lagoon with XR-5 material.
Year Installed	Cover installed 1992. Engine installed 1994.
Designer/Installer	<i>Cover:</i> L.M. Safley Jr., N.C. State University/Carroll's Foods of North Carolina. <i>Engine:</i> Caterpillar, Inc./Charles R. Browning & Associates
Gas Production	29,000 ft <sup>3</sup> /day (80% CH <sub>4</sub> )
End Uses of Biogas	Electricity production
Engine Type	110-kW Caterpillar 3306
Operational Mode	Isolated, Synchronous.
Utility Contract	No Sale.
Electricity Production	Not available.
End Uses of Effluent	Land application from second lagoon cell.
Operational History	Lagoon cover ripped and sank, 1995. Replacement planned in 1997.
Routine Maintenance	Not available.
COST & REVENUE INFORMATION	
Capital Cost	est. \$300,000.
O&M Cost	\$8,000 to \$10,000 projected.
Electricity Offsets	Not available. \$0.06 is current kWh charge, with \$12 demand charge.
Heating Benefits	Production: Not available. Offsets: Not available.
Estimated Financial Performance	IRR (%): Not available. Payback (yrs): Not available.
OPERATOR COMMENTS	
What do you like about your system?	
What would you change about your system?	
Other comments: <i>Project sponsored by North Carolina Energy Division and Carroll's Foods of North Carolina.</i>	
<i>Sources:</i> 1. Personal Communication with Dr. David Beasley, Biological and Agricultural Engineering Department, North Carolina State University, May 1997. 2. DOE, 1995, "Methane Recovery from Animal Manures: A Current Opportunities Casebook," August 1995. 3. North Carolina Energy Division, "Low Temperature Lagoon Digester For Biogas Production From	

Swine
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Manure”, Report Date: Sept. 1993.
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## 21. Lou Palmer Farm

*Covered Lagoon for Swine Manure*

GENERAL FACILITY INFORMATION		
Location	Morrilton, AR	
Contact/Source	Jim Wimberly -- (501) 727-5435	
Farm Type	300 sow farrow-to-feeder swine farm	
Utility	Not applicable	
BIOGAS SYSTEM INFORMATION		
Digester Type	Covered lagoon with internal drainage	
Year Installed	1992	
Designer/Installer	Resource Conservation Management, Inc./Winrock International	
Gas Production	3,200 ft <sup>3</sup> /day in summer (80% CH <sub>4</sub> ) 1,400 ft <sup>3</sup> /day in winter (80% CH <sub>4</sub> )	
End Uses of Biogas	None.	
Engine Type	Not applicable.	
Operational Mode	Not applicable.	
Utility Contract	Not applicable.	
Electricity Production	Not applicable.	
End Uses of Effluent	Not applicable	
Operational History	Floating cover deteriorated during removal after fourth year.	
COST & REVENUE INFORMATION		
Capital Cost	\$16,000	
O&M Cost	Estimated less than \$500.	
Electricity Offsets	Not applicable	
Heating Benefits	Production: equivalent of 12-13 gallons of propane per day (1.12 million BTU)	Offsets: estimated at \$1,400 for heating season (Oct - Mar) @ \$0.6/gallon propane
Estimated Financial Performance	IRR (%): Not available.	Payback (yrs): Not available.
OPERATOR COMMENTS		
What do you like about your system?		
What would you change about your system?		
Other comments: <i>Project sponsored by the Southeastern Regional Biomass Energy Program (SERBEP) to demonstrate low-cost floating cover technology on smaller-scale (marginal) systems. Removed from service in 1996.</i>		
Source: 1. Personal communication with Jim Wimberly, Winrock International. 2. DOE, 1995, "Methane Recovery from Animal Manures: A Current Opportunities Casebook," August 1995.		



## 22. Martin Farms

*Covered Lagoon for Swine Manure*

GENERAL FACILITY INFORMATION	
<b>Location</b>	South Boston, VA
<b>Contact/Source</b>	Debbie & Harold Martin -- (804) 476-6613
<b>Farm Type</b>	600 sow farrow-to-finish swine farm
<b>Utility</b>	Virginia Electric Company
BIOGAS SYSTEM INFORMATION	
<b>Digester Type</b>	Covered lagoon with XR-5 cover material
<b>Year Installed</b>	1993
<b>Designer/Installer</b>	Original Cover - AgriWaste Technology, Inc./Carroll's Foods of VA. Replacement Cover -Engineered Textile Products, Inc., and Resource Conservation Management, Inc.
<b>Gas Production</b>	12,000 ft <sup>3</sup> /day (80% CH <sub>4</sub> ) on average.
<b>End Uses of Biogas</b>	Electricity withwith planned heat recovery to nursery.
<b>Engine Type</b>	25-kW model H225 Chrysler marine engine with a Kato generator.
<b>Operational Mode</b>	Parallel Induction.
<b>Utility Contract</b>	Offset, No Sale.
<b>Electricity Production</b>	150,000 to 175,000 kWh
<b>End Uses of Effluent</b>	Digester effluent goes to the second-cell storage lagoon and is later recycled to flush the swine houses on a continuous cycle. Excess liquids from the second cell are land-applied.
<b>Operational History</b>	Original cover partially sank; Cover replaced, 1997 - Resource Conservation Management, Inc.
<b>Routine Maintenance</b>	20 minute daily check of equipment. Engine oil changed every 300 hours.
COST & REVENUE INFORMATION	
<b>Capital Cost</b>	\$85,128
<b>O&amp;M Cost</b>	\$2,500 /yr
<b>Electricity Offsets</b>	Estimated at \$10,625. \$0.065 is the current kWh charge.
<b>Heating Benefits</b>	Production: Not available. Offsets: Not available.
<b>Estimated Financial Performance</b>	IRR (%): Not available. Payback (yrs): Not available.
OPERATOR COMMENTS	
What do you like about your system? <i>Odor control.</i>	
What would you change about your system? <i>Better cover design, more heat use in barn.</i>	
Other comments: <i>Project sponsored by SERBEP, Carroll's Foods of VA, and Engineered Textile Products, Inc.</i>	
<i>Source: 1. Personal communication with Dave Stephenson, Assistant Manager, Southeastern Regional Biomass Program, 1997</i>	

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| 2. DOE, 1995 “Methane Recovery from Animal Manures: A Current Opportunities Casebook,” August 1995. |
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## 23. Sharp Ranch

*Covered Lagoon Digester for Swine Manure*

GENERAL FACILITY INFORMATION		
Location	Tulare, CA	
Contact/Source	Roy, Gene, David Sharp -- (209) 688-2051	
Farm Type	500 sow farrow to finish swine farm	
Utility	Southern California Edison	
BIOGAS SYSTEM INFORMATION		
Digester Type	Covered Lagoon, Permalon material	
Year Installed	1985	
Designer/Installer	Roy and David Sharp/Sharp Energy	
Gas Production	Average 24,550 ft <sup>3</sup> /day	
End Uses of Biogas	Electricity, hot air for nursery pigs	
Engine Type	Waukesha	
Operational Mode	Parallel Induction	
Utility Contract	Net Metering	
Electricity Production	270,100 kWh/yr, 740 kWh/d	
End Uses of Effluent	Fertilizer	
Operational History	No major problems	
Routine Maintenance	Oil changes	
COST & REVENUE INFORMATION		
Capital Cost	Not available.	
O&M Cost	Not available.	
Electricity Offsets	\$31,300	
Heating Benefits	Production: Not available.	Offsets: \$4,360
Estimated Financial Performance	IRR (%): Not available.	Payback (yrs): Not available.
OPERATOR COMMENTS		
What do you like about your system? <i>Ease of operation.</i>		
What would you change about your system? <i>Not much, maybe larger lagoon</i>		
Other comments: <i>Most sows and boars kept outdoors, manure does not enter lagoon</i>		
<i>Source: 1. Personal communication with David Sharp, 1997.</i>		



2. Personal communication with Sharp Ranch, 1996.

## 24. Cushman Dairy

## *Complete Mix Dairy Digester*

GENERAL FACILITY INFORMATION	
Location	North Franklin, CT
Contact/Source	Nathan Cushman --(860) 642-4711
Farm Type	600 cow dairy; expanding to 900-1,200 cow capacity
Utility	Connecticut Light & Power
BIOGAS SYSTEM INFORMATION	
Digester Type	Complete Mix
Year Installed	1996-7
Designer/Installer	Agri-Bio Systems, Inc./Mohawk Tech
Gas Production	Not available
End Uses of Biogas	Generate electricity
Engine Type	Kohler package
Operational Mode	Synchronous/Stand-Alone capacity.
Utility Contract	Net Metering.
Electricity Production	Not available.
End Uses of Effluent	Solids Recovery -Bedding, compost Liquids Recovery - Fertilizer
Operational History	Not available.
Routine Maintenance	Normal maintenance - engine, separator, pumps.
COST & REVENUE INFORMATION	
Capital & O&M Cost	Capital: Not available; O&M: Not available.
Electricity Offsets	Not available.
Heating Benefits	Production: Not available. Offsets: Not available.
Financial Performance	IRR (%): Not available. Payback (yrs): Not available.
OPERATOR COMMENTS	
What do you like about your system?	
What would you change about your system?	
Other comments:	
Source: Agri-Bio Systems, Inc., April, 1997	



## 25. Name of Facility]

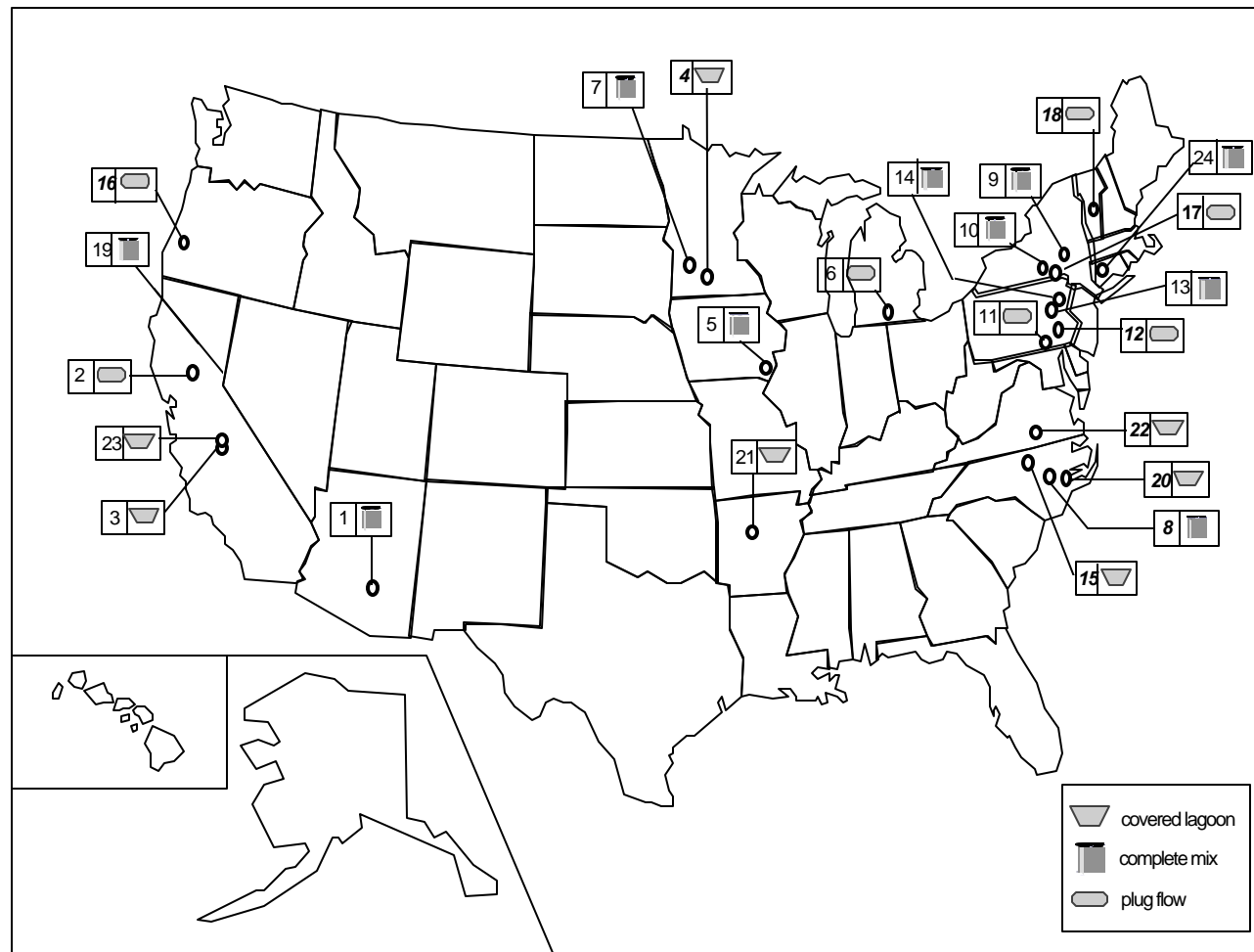
GENERAL FACILITY INFORMATION	
Location	
Contact/Source	
Farm Type	
Utility	
BIOGAS SYSTEM INFORMATION	
Digester Type	
Year Installed	
Designer/Installer	
Gas Production	
End Uses of Biogas	
Engine Type	
Electricity Production	
End Uses of Effluent	
Operational History	
Routine Maintenance	
COST & REVENUE INFORMATION	
Capital & O&M Cost	Capital: \$ _____; O&M: \$ ____ /yr
Electricity Offsets	
Heating Benefits	Production: _____ Offsets: _____
Financial Performance	IRR (%): _____ Payback (yrs): _____
OPERATOR COMMENTS	
What do you like about your system?	
What would you change about your system?	
Other comments:	
Source:	



# Appendix A Profiles of U.S. Farm Digester Sites

## Sites Profiled:

1. Arizona Dairy Company .....A-1
2. Langerwerf Dairy .....A-2
3. Royal Farms .....A-3
- 4. Churchill Co-op.....A-4**
5. McCabe Farms .....A-5
6. Fairgrove Farms, Inc.....A-6
7. Lindstrom Farms .....A-7
- 8. Darrell Smith Farm .....A-8**
9. Cooperstown Holstein C.F.....A-9
10. Agway Farm Research Ctr.....A-10
11. Mason Dixon Farms .....A-11
- 12. Rocky Knoll Farms.....A-12**
13. Oregon Dairy Farms .....A-13
14. Valley Pork.....A-14
- 15. Barham Farms.....A-15**
- 16. Craven Dairy. ....A-16**
- 17. AA Dairy.....A-17**
- 18. Foster Brothers Farm .....A-18**
19. M&M Dairy .....A-19
- 20. Carroll's Foods, Inc. ....A-20**
21. Lou Palmer Farm.....A-21
- 22. Martin Farms.....A-22**
23. Sharp Ranch.....A-23
24. Cushman Dairy .....A-24



**Bold denotes AgSTAR Partner Farm**